

DOCUMENT RESUME

ED 345 485

FL 019 501

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TITLE Second Language Speech Perception: The Flip Side of the Phonological Coin.
PUB DATE 88
NOTE 16p.; For the journal as a whole, see FL 019 498.
PUB TYPE Information Analyses (070) -- Journal Articles (080)
JOURNAL CIT Texas Papers in Foreign Language Education; v1 n1 p26-40 Spr 1988

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Bilingualism; Dialects; *Language Acquisition; Language Research; *Phonetics; *Phonology; *Pronunciation; *Second Language Learning; *Speech Communication

ABSTRACT

Speech perception research is reviewed and organized around issues relevant to second language acquisition. Issues discussed include the concept of a critical period for speech perception as well as the effects of linguistic training and/or linguistic experience on speech perception. Speech perception in bilinguals, the relationship between speech perception and production, and perception of accent are also reviewed to provide additional insight into second language speech perception. Throughout, "speech perception" refers to phonetic/phonological segmental perception; the role of suprasegmentals in speech perception is not addressed. It is concluded that speech perception might play a significant role in second language acquisition. It appears that speech perception is related not only to speech production, but also to overall language proficiency even though the extent and direction of these relations have yet to be determined. Contains 49 references. (LB)

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Second Language Speech Perception: the flip side of the phonological coin

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In the study of the sound system of language, phonology, the bulk of theory and research has revolved around language output, the product of language. In a linguistics chronology, speech perception research is at best at an adolescent stage. In much the same way, theory and research on phonological acquisition has taken the same route, beginning by concentrating on speech that has been produced by infants and developing children. Only in the last decade and a half has the study of infant speech perception really developed. It is little wonder then that in the field of second language acquisition, schooled in linguistics and a grade behind language acquisition, researchers have concentrated on language output and little research has been devoted to the topic of second language speech perception.

In this paper, speech perception research will be reviewed and organized around issues relevant to second language acquisition. Issues to be discussed include the concept of a critical period for speech perception as well as the effects of linguistic training and/or linguistic experience on speech perception. Speech perception in bilinguals, the relationship between speech perception and production, and perception of accent will also be discussed to provide additional insight into second language speech perception. Finally, conclusions concerning the role of speech perception in second language acquisition will be drawn and suggestions for further research will be offered.

When referring to speech perception throughout this paper, I will mean phonetic/phonological segmental perception. The role of supra segmentals in speech perception will not be addressed. In addition, the terms "perceive" and "process" will be used interchangeably.

Theories of Speech Perception

Theories of speech perception have generally followed two lines of thought; those that support a special speech processor and those which posit one auditory processor for both speech and nonspeech. Recently, theories positing dual or multi-level processors have been developed.

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Those theories that posit a special speech processor include the so called "motor theory" (eg. Liberman et al., 1967), the theory known as "analysis by synthesis" (Stevens & Halle, 1967), and theories which posit special feature detectors in the process of speech perception (eg. Abbs & Sussman, 1971).

Schouten (1980), however, claims that speech is perceived in the same way as non-speech, on a purely auditory level. He reviews evidence that questions the idea of a special speech processor and concludes that, although such a special speech mode may exist, there appears to be insufficient evidence for such a claim.

Finally, there are also theories which posit a multiple processor for speech, (eg. Werker & Logan, 1985). These theories claim that the speech signal is first processed acoustically and then phonetically. The auditory level is where the acoustic information is transformed into a neurally encoded phonetic signal. At the phonetic level, the acoustic signal is transformed into different phonetic values. The phonetic units are then converted into phonological values before the higher level processing (eg. semantic) takes place.

All these theories have been developed as a result of first language speech perception research. It is unclear then where second language speech perception fits in. Is speech perception language specific? Is there a different perceptual process and/or system for a second language or is the first language the perceptual base for the second language? In fact, concepts of speech perception that are concerned with second language learning appear to be based on one of the models discussed above for first language speech perception.

Infant Speech Perception and a Critical Period

Much of the research concerning infant speech perception has taken place in the last fifteen years. The pioneering study of infant speech perception is that of Eimas et al. (1971). The results of his experiments, in which he tested discrimination of consonants along a voice-onset time (VOT)¹ continuum, indicated that infants (1-4 mos.) perceived voicing qualities and that they perceived them categorically.² This implied that speech perception may be operating

¹ VOT is the time between closure of the stop (e.g., [p b]) and the beginning of voicing. VOT quality has been isolated for a number of languages (Abrahamson and Lisker, 1970) and is often used as a feature to study speech perception.

² Categorical perception is another phenomenon used in the study of speech perception. Simply described, it is when a range of sounds are perceived as

at a very early age, perhaps even from birth. Much research has been done on infant speech perception since this first study. (See Jusczyk, 1981 for a review.)

Though the concept of an innate special speech processor is not the focus of the present discussion, evidence accumulated while investigating infant speech perception has raised a question relevant to the area of second language speech perception. That is, is there a critical period for speech perception in general and second language speech perception by implication?

In an experiment with infants from a Spanish-speaking environment which investigated their ability to discriminate along a voicing continuum, researchers found the VOT boundaries to be quite similar to that of the Eimas et al. infants even though the boundaries for the same VOT continuum would be quite different for the adults of each language group (Lasky et al., 1975). This evidence indicated that infants could perceive phonetic contrasts not native to their own environment. Another experiment contrasted the perceptual abilities of infants and adults from an English-speaking environment to discriminate sounds from Czech (Trehub, 1976). These results indicated that infants could discriminate foreign speech sounds much better than adults. This raised the question of whether there was some biological boundary for speech perception as has been posited for speech production (eg. Lenneberg, 1967).

In an experiment that tested a number of language capabilities including discrimination, Snow and Hoefnagel-Hohle (1978) found that adolescents were better than young children at discrimination tasks and that adults were the next best. In fact, children had the worst scores. Their findings were consistent with the results of an earlier experiment (Politzer & Weiss, 1969), which found that older children outperformed younger children on perceptual tasks.

More recently, in the first of a set of experiments by Werker and her colleagues (1981), a number of interesting findings regarding a critical period for the perception of speech have been reported. Using a discrimination task involving Hindi dental/retroflex contrasts, it was found that 6 month old Canadian children with no background in Hindi were able to discriminate between these contrasts in much the same way as Hindi-speaking adults. They repeated this experiment with four year old English-speaking

belonging to specific phonemic categories rather than along a continuum from one sound to another.

children and found that they were incapable of discriminating the same contrasts (Werker & Tees, 1983). In yet another experiment, they found that although 8-10 mos. old infants were able to discriminate between the sounds, infants just 2 mos. older had the same poor results as four year olds. Retesting those same 8-10 month old children two months later, they found that these infants had lost the ability to discern the contrasts (Werker and Tees, 1984). Another researcher (Burnham, 1986) has posited two critical periods for the *loss* of speech perception capabilities. The first period is consistent with the evidence from Werker et al. at 6-12 mos. He suggests that loss of speech perception capabilities during this period occurs due to lack of exposure to relevant phonetic stimuli. The second period he posits to be between the ages of four and eight and suggests that the loss this time is due to lack of phonetic experience. He suggests that the results of loss during the first period might be extremely difficult to reverse while those capabilities lost during the second period would be, in comparison, much easier to reacquire.

Thus, it could be posited there is a critical period for speech perception and it might be best to posit this as a critical period for loss of perception. However if, as both Werker et al. and Burnham suggest, the boundary for this critical period exists at around 8 mos., this concept would appear to have little impact on second language acquisition for obvious reasons. First, infants at this stage cannot accurately be said to be acquiring a second language. Even in a bilingual environment, the process of acquisition would appear, at that time, to be more closely related to (dual) first language acquisition rather than second language acquisition. Further evidence for questioning the utility of positing such a critical period for speech perception is the apparent capability of children and adults beyond this stage to process a second language. So, although such a critical period might indeed exist, its effects appear to be reversible later and thus its impact on second language acquisition would be minimal.

Linguistic Experience and Speech Perception

However, this loss of sensitivity to nonnative sounds raises the question of how linguistic experience might affect speech perception. As this loss of sensitivity does not appear to be due to neural decline (Werker & Tees, 1984), it may be due to native linguistic experience. In an experiment with Kikuyu children (Streeter, 1976), in which they were tested for discrimination along

a VOT continuum, results showed both the ability to discriminate qualities that they were not exposed to as well as some qualities of voicing that they had experienced in their native environment. In contrast to those theories that support the idea of an innate speech processor, Simen and Fourcin (1978), in a cross language study of speech pattern learning, concluded that categorical labeling of speech sounds is not innate but rather learned and to some extent, language specific. Werker (1984), in one of her many experiments concluded that this loss of perceptual ability discussed above was, in fact, due to linguistic experience.

This role of linguistic experience in speech perception appears to suggest that speech perception might be language specific. Studying the development of speech perception in growing children, Zlatin and Koeingsknecht (1975), found evidence that there may be developmentally related age differences in perception of the voicing contrasts. They found that as the subjects got older, they narrowed their perceptual boundaries. Flege and Eefting (1986) found evidence that indicated that auditory processing might change with age. They found that Spanish- and English-speaking children and adults perceive different VOT values for their respective languages concluding that adults were narrower in their perception due to more linguistic experience in the native language. From a second language perspective, Flege (1985) theorizes that not only is perception language specific, but that second language learners map out second language sounds through their own first language phonetic "chart". Scholes (1968) had claimed earlier that categorization of English vowels by non-natives is also based on their native language categorizations. Even earlier, Sapon and Carroll (1958), claimed that there was a significant difference in perception based on native language. This is supported by a more recent study from which the researcher concluded that second language learner perception is fundamentally different than native speaker perception (Gass, 1984).

Further evidence of a language specific perceptual speech mechanism comes from studies of adult learners, which show their failure to discriminate sounds that are not in their native language. In an oft-cited study by Miyawaki et. al., (1972), English and Japanese subjects were asked to discriminate between /r/ and /l/. It was found that Japanese learners, for whom this contrast was not native, had a poor ability of discrimination. In a similar study (Mackain, Best & Strange, 1981), evidence also indicated that experience had a positive effect on discrimination. In this experiment, those Japanese

subjects who had had English at school when they were younger were able to distinguish the /r/-/l/ contrast significantly better than those who had not. Flege (1984) also found that Arab subjects who had had more English experience outperformed those who had had very little in a VOT discrimination task. In a more recent study involving multilingual subjects (Werker, 1986), results indicated that not only does experience aid discrimination but that this experience must be specific. In other words, simply a broader base of phonetic perceptual experience will not aid discrimination of a phonetic contrast not in the realm of this experience.

From this evidence, it would appear that speech perception develops according to the linguistic environment of the subject, and might be language specific. This theory raises two new issues that must be considered: Can first language speech perception be modified to incorporate a second language? Do bilinguals and second language learners have two separate systems of perception, one for each language?

Bilinguals and Speech Perception

Caramazza et al., (1973) tested French-English bilinguals in Canada for stop consonant perception and production. His findings indicated that although the subjects seemed to have two systems of production, they had a single perceptual system intermediate to monolingual speakers of both languages. Further tests on Hebrew-English bilinguals (Albert & Obler, 1978) and Icelandic-English bilinguals (Garnes, 1977) produced similar results.

These findings combined with evidence reviewed earlier might suggest that language learners process the second language through the perceptual system of the first language, modifying and adding to an already existing system rather than creating a new one. It could follow then that bilinguals, both early and late, do much the same thing, the former developing with one system for both languages while the latter would just adjust the first system to accommodate the second language.

It should be noted that in the studies cited above, although bilinguals seemed to have a unitary system for perception, the perceptual system of the bilingual was different from the systems of monolingual native speakers of both languages.

Linguistic Training and Speech Perception

The second issue raised by the theory that speech perception develops specific to the language environment of the individual, is

whether the developed system can be modified by linguistic training. In 1966, Henning claimed that training could aid not only the teaching of pronunciation, but also the discrimination of sounds. However, Strange and Dittman (1984) studying the effects of discrimination training on the perception of /r/-/l/ by Japanese adults learning English concluded that modification of the first language perceptual system is slow and effortful and that training had little effect. This supported their earlier conclusions after an experiment which attempted to train English speakers to discriminate a three-way contrast in Thai (Strange & Jenkins, 1978). Their conclusion was modified somewhat by Tees and Werker (1984), who concluded that although subjects could be extensively trained to discriminate these contrasts, training had little long term effect; i.e., the perceptual system could be modified temporarily, but there was a "use it or lose it" process which took place.

Jamieson and Morosan (1986), using a different technique than Strange and Dittman, studied the effects of training on the perception of the /ð/-/θ/ contrast in English on Francophones. They concluded that adult perception of non-native speech sounds improved with training and that perception has a higher degree of plasticity than performance.

In an earlier study than the one cited above, Werker and Tees (1981) concluded that training could help adult discrimination along the VOT continuum. Similarly, Streeter and Landauer (1976) attributed some of the ability of Kikuyu learners to discriminate along the VOT continuum to the training they received.

In two recent studies, (Pisoni et al., 1982; McClaskey et al., 1983), in which subjects were trained to perceive a 3-way stop contrast, researchers found evidence that perceptual mechanisms used by adults can be modified by simple techniques. They concluded that discrimination training facilitates the ability to discriminate and that the adult speech processing system has a higher degree of plasticity than previously thought.

From this evidence, it appears that training can have an effect on speech perception abilities leading to incorporation of second language phonetic contrasts. However, differing results for the various experiments suggest that technique may play a fundamental role. There is also some evidence, however, that the modifications will not remain if the training stops and that extensive training is needed to effectively "change" the existing perception system of the learner.

Perception vs. Production

Related to the question of how both linguistic training and experience affect speech perception, is the issue of how modification of the perceptual system relates to the production system of the learner.

Regarding this issue, there again is little empirical evidence on the relationship between perception and production. Proponents of the motor theory would posit that there is a dependance of one of these systems on the other: that speech perception is dependant on speech production.

However, according to evidence from studies of bilinguals, also cited above, there appears to be a certain independence of perception in relation to production.

On the issue of order of acquisition, one study and its replication, which investigated the perception of the /r/-/l/contrast in English by Japanese adults (Goto, 1971; Sheldon & Strange, 1982) produced evidence that production can in fact precede perception in adults. Results showed that although some of the subjects could produce the contrasts accurately, they could not discriminate them even in their own productions.

On the other hand, studies with children provide evidence that perception precedes production. Edwards (1974) found that perception generally precedes production even though order of perception and order of production may not be identical. Williams' study (1979) of bilingual Spanish-English children also found that there was a shift in the production of words which accompanied the children's shift in perception.

This difference in order of perception and production between children and adults may be due to the earlier development of speech perception in children. Whereas adults would have fully developed speech perception and production systems, the child would have to use what it had available. If the system of speech perception began to develop in prelinguistic children, it would seem logical for speech perception abilities to precede production abilities.

There appears to be a large gap in the research between the young child and the adult. In order to learn more about the relationship of production and perception, more research is needed on subjects between these two maturational extremes.

Perception of Accent

To summarize our discussion so far it appears that speech perception develops, at least to some extent, specific to the native

language environment of the individual. Although the individual's perceptual system appears to be modifiable through linguistic experience and training, this modification may have as its base the phonetic representations for the sounds of the first language. Some additional support for these assertions comes from studies of perception of accent.

Let us assume for the sake of our discussion that accent does occur and is perceived by native speakers. Although a complete discussion of how accent is perceived is beyond the scope of this paper, what is perceived as accent may be assumed to be those elements not included in the phonological/phonetic inventory of the native language. This supports the idea that speech perception may be language specific in so far as these unfamiliar elements would be perceived either as acoustic noise or as something foreign or strange. If second language learners can perceive accent in other samples of non-native speech, then we might have evidence that speech perception is modifiable. That is, that the L2 learners have added these once strange or foreign elements to their perceptual repertoire so that sounds not familiar to the L2 now are the cause of the perception of an accent.

Flege (1985) has indeed hypothesized that these detailed phonetic representations of the sounds in the native language enable the listener to detect accent in non-native speech. That is, that the lack of correspondence between that which is perceived and those phonetic representations, cause the listeners to hear something unfamiliar and foreign, i.e., an accent. In one of four experiments he performed, Flege also found evidence that detection of accent by a native speaker was not dependant on any experience in the speaker's native language. Further, he found that native speakers could detect accent in short phrases, CVsyllables, phonetic segments and even bits of phonetic segments. If native speakers detect accent and they are able to do so with such minute bits of linguistic information, would second language learners be able to detect accent in other non-native speech in the same way and to the same extent?

Gass (1984) tested adult ESL learners and native English speakers on their abilities to discriminate along a VOT continuum from /b/ to /p/. She found that perception of the VOT qualities of the first language was fundamentally different than the VOT qualities of the second language. In fact, she found that the VOT qualities for the L2 were perceived continually while these qualities in the first language are perceived categorically. She also found evidence that perception of the L2 was influenced by both first language and target

language VOT qualities. Two further experiments (Sheldon & Strange, 1982; Goto, 1971) in which Japanese ESL learners and native English speakers were tested on their ability to discriminate /r-l/ found that native speakers were better at perceiving accent than non-natives. These studies suggest that the first language speech perceptual apparatus does indeed affect second language speech perception. One consequence of this is that second language learners do not detect foreign accent in the target language as accurately as native speakers.

Scovel (1981) also investigated this aspect of perception and found again that non-native speakers could indeed detect accent but that they were not as good as native speakers. Interestingly, he tested three ability levels of second language learners and found that as the language ability of the learner increased so did their ability to detect accent in non-native speech. Recently collected data by this author produced evidence that learners with a higher proficiency level in the second language were more accurate at detecting accent in non-native speech (Baldzikowski, 1988). This evidence supports the idea that the perceptual system can be modified in the direction of the second language and that experience and training do indeed produce just such an effect.³

Summary

Although the literature relevant to second language speech perception is recent and somewhat sparse, that which we have reviewed enables us to make some interesting observations.

From the evidence it appears that there is a critical period for speech perception at about the age of 8-10 months. After that, speech perception develops as a function of the specific language environment of the individual.

This language specific perceptual system appears to be sensitive to modification either through linguistic experience or linguistic training. There is also some evidence suggesting that greater second language proficiency and accurate speech perception are related.

There also appears to be evidence that the systems of speech production and perception interact but it is not clear how and in what way. In bilinguals, evidence suggests that although there may be two systems for speech production, one for each language, there is

³ It should be noted that the above discussion is concerned with the phonetic aspects of accent rather than the social or psychological perception of accent.

only one intermediate level of speech perception. This may be the case for second language learners as well, i.e., second language learners simply modify and adjust their speech perception apparatus to account for new linguistic characteristics rather than developing an entirely new perceptual system.

Conclusions and Directions for Future Research

All of this evidence suggests that speech perception might play a significant role in second language acquisition. It appears that speech perception is not only related to speech production but to overall language proficiency even though the extent and direction of these relations have yet to be determined. There is also ample evidence that speech perception is modifiable, both through training and experience. It might be then that in the process of acquiring a second language, speech perception plays the initiating role upon which all other language factors such as production and comprehension are based. Yet, even if such speculation appears to stretch the evidence reviewed here, suggesting that speech perception at least facilitates the acquisition of a second language does not appear to lack support.

However, research in speech perception, which can be related to second language acquisition, is sparse and there are many gaps that need to be filled in.

To address the differences in the development of speech perception from infancy to adulthood, speech perception research investigating children and adolescents is needed. Such research would also help answer questions concerning age-related perceptual flexibility.

Any and all research concerning how the perceptual system of the individual is modified to account for new speech characteristics would be invaluable for the field of second language acquisition. Techniques which facilitate this modification need to be developed and tested. Tracking these modifications in second language learners over time would help illustrate the role of speech perception in second language acquisition. Studying non-native perception of accent may be one way of doing this.

The relationship between perception and production also needs to be investigated to address the issue of whether there are perceptual bases for production difficulties in second language learners and vice versa. Is there a sensitive period in the relationship between perception and production of speech? Is there a perceptual basis for accent?

Upto now, researchers have paid little attention to speech perception in the study of second language acquisition. Although second language speech has been used to study speech perception, this is not true in reverse. Yet, evidence indicates that speech perception might play a role in second language acquisition. For this reason alone, second language speech perception merits further research.

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